Novel Acoustic Projectors for Non-Lethal Swimmer Deterrence

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LONG-TERM GOALS

The goal of this project is to assess the viability of non-traditional underwater acoustic projectors for applications in which high-fidelity or complex transmitted waveforms are not required. Underwater acoustic transduction is dominated devices based on piezoelectric and magnetostrictive drives. This project is intended to assess electro-mechanically (motor) driven approaches for *non-critical* applications.

OBJECTIVES

The primary technical objective of this effort is to complete the development and assessment of a variable-output, motor-driven, underwater acoustic projector. The development of the motor-driven projector was begun on a previous contract (N00014-06-C-0101).

APPROACH

The current effort is actually the third and final phase in the development of a variable-output, motor-driven, underwater acoustic projector. The first phase assessed the likelihood that a motor-driven projector could be developed that would provide useful acoustic output but would have a recurring cost significantly less than a conventional piezoceramic-drive projector and associated power amplifier. That study, conducted in 2006 concluded that a low-cost motor-driven projector was possible. Following the study, the second phase of the project developed and tested a fixed-output, motor-driven projector. This phase culminated in acoustic characterization testing of the fixed-output device at the Naval Undersea Warfare Center Dodge Pond test facility.

Based on the lessons learned from the fixed-output prototype, we began development of a variable-output device. In order to constrain the problem, non-lethal swimmer deterrence was chosen as the application for this projector. This application dictated the frequency range of the projector – 35-100 Hz, as well as the acoustic output level – variable up to 190 dBre1μP at 1 m.

On the fixed-output device, we used an inverse flextensional (Class VII) shell driven by an elliptical camshaft. Figure 1 below shows the partially assembled fixed-output projector. The cam can be seen protruding from the center of the inverse flextentional shell.

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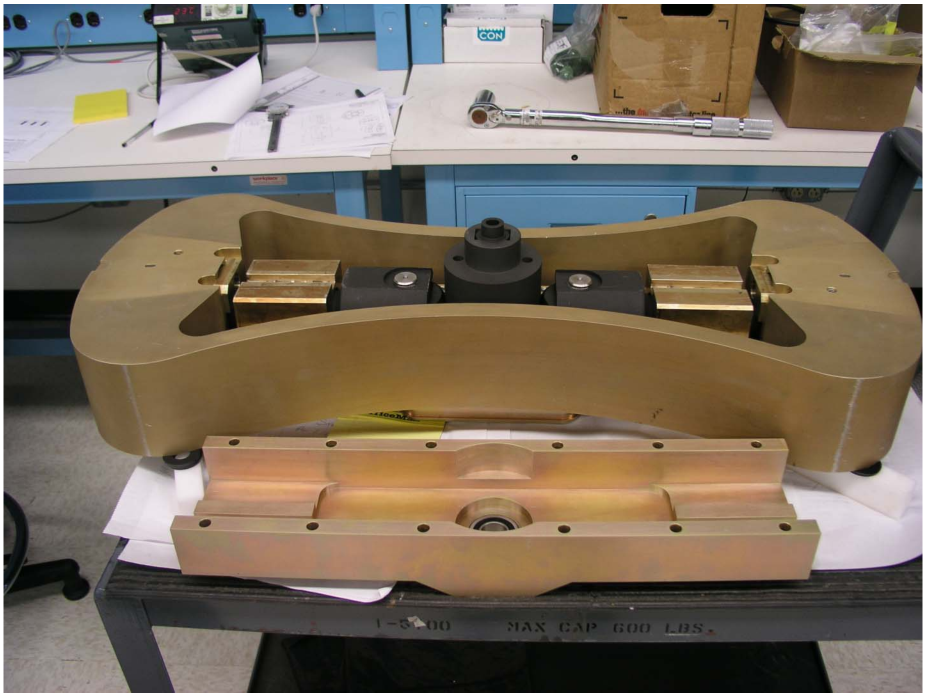

Figure 1. The elliptical cam and followers (black parts) are shown in the center of the inverse flextensional shell.

We determined from the fixed-output effort that a flextensional shell would be too stiff for the motor-driven application. So, for the variable output projector, we opted for a slotted-cylinder based architecture in which the slot was driven open by action of the cam. Figure 2 below depicts the geometry of the shell used for this effort.

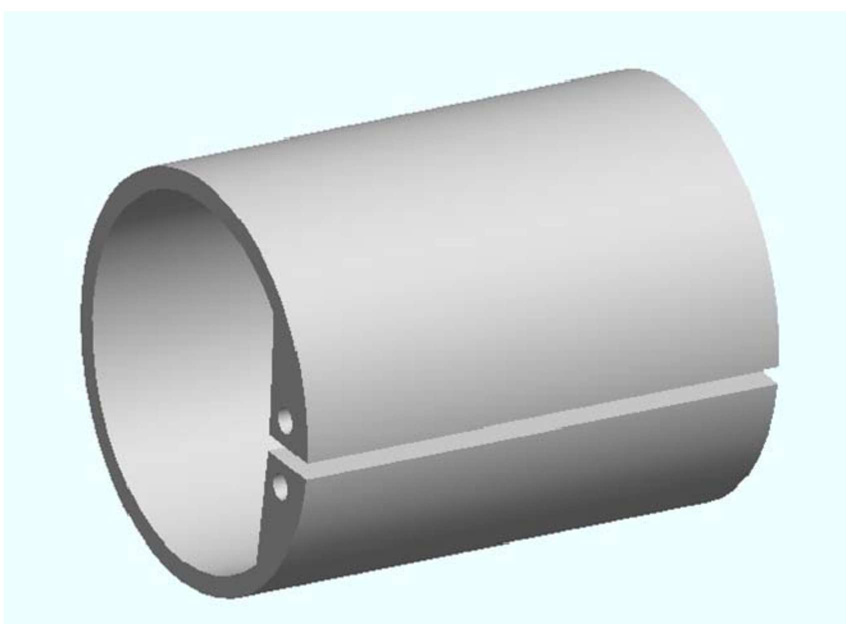

Figure 2. Slotted cylinder geometry used for variable-output projector.

WORK COMPLETED

As of the date of this report, we have completed the design, fabrication, and mechanical assembly of the variable-output projector. We have manually turned over the drive system and associated camshaft and are in the process of verifying the variable output aspect of the design.

We started this year's effort in the late spring of 2008. At that time, approximately half of the machined components and piece-parts for the projector were on hand. Some aspects of the mechanical design needed to be finalized. All design work was completed and all components were procured. Assembly took place in early summer of 2008 with initial testing commencing in September.

RESULTS

The cam-drive mechanism worked exactly as intended when tested by manually turning the shaft. Rotating the shaft by hand, with the variable deflection control set approximately to the middle of its range, we verified end-to-end the mechanical operation of the projector. This was primarily a concept and design verification that confirmed the correct design, fabrication, and assembly of the projector. The complexity of this design approaches that of the valve drive mechanism on an internal-combustion engine. The mere fact that the parts went together and turned over as expected has gone a long way to retiring the design risk associated with such a complex design. We are now moving on to testing the variable-displacement aspect of the design.

IMPACT/APPLICATIONS

This project was undertaken to demonstrate a low cost, *low-tech*, alternative to conventional underwater acoustic projectors. The conventional approach which typically uses a piezoceramic motor driven by a power amplifier has seen many decades of development and refinement. The result is now compact, high output, high fidelity, high bandwidth, underwater acoustic projectors. They tend, however, to be costly. There are a number of applications which do not require the fidelity or bandwidth now available. They include non-lethal swimmer deterrence for platform and harbor defense, fish diversion for cooling water and industrial intakes, acoustic mixing and agitation, as well as a subset of more conventional sonar applications. For all these applications, an approach optimized to providing the required output but at significantly lower cost is desirable. This effort to develop a low-frequency, variable output level, underwater acoustic radiator has potential application in a number of these areas.

TRANSITIONS

Transition opportunities exist within the Navy for platform (PMS 480) and harbor security (NAVFAC PM for ATFP) as well as within the Department of Homeland Defense.

RELATED PROJECTS

This program falls within the scope of the ONR 321 D&I *Underwater Threat Neutralization* effort.